# ANNEX D

# DROUGHT

## I. TYPE OF HAZARD

Drought

## II. DESCRIPTION OF HAZARD

Drought is not a hazard that affects just farmers, but can impact the nation's entire economy. Its outcome can adversely affect a small town's water supply, homeowners, the corner grocery store, commodity markets, and tourism. According to the National Drought Mitigation Center, drought costs the U.S. economy about $7 to 9 billion dollars a year. Losses from the 1988-1989 drought were projected by Chamgnon and Riebsame and White House Study Group at $39.2 billionfor 1988, including about $51.6 billion in agricultural losses. The University of Missouri estimated the drought losses of 2002 and 2003 farm production years. Economic impact to the Missouri economy due to agricultural losses were $461 million for 2002 and $575 million in 2003.

The dictionary defines drought as a period of prolonged dryness. The Missouri Drought Response Plan distinguishes between five "categories" of drought, as follows:

1. **Agricultural Drought**, defined by soil moisture deficiencies

2. **Hydrological Drought**, defined by declining surface and groundwater supplies

3. **Meteorological Drought**, defined by precipitation deficiencies

4. **Hydrological Drought & Land Use,** defined as a meteorological drought in one area that has hydrological impacts in another area

5. **Socioeconomic Drought,** defined as drought that impacts supply and demand of some economic commodity.

Each of these definitions relates the occurrence of drought to water shortfall in some component of the hydrological cycle. Each affects patterns of water and land use, and each refers to a repetitive climatic condition. In urban areas, drought can affect those communities that depend on reservoirs for water, and decreased water levels due to insufficient rain can lead to restricted water use. In agricultural areas, drought during the planting and growing season can have a significant impact on yield.

The U.S. Government's definition of an agricultural drought incorporates specific parameters based on historical records. Agricultural drought is "a combination of temperature and precipitation over a period of several months leading to a substantial reduction in yield (bushels per acre) of one or more of the three major food grains (wheat, soybean, corn). A substantial reduction is defined as a yield (bushels per acre) less than 90% of the yield expected with temperature/precipitation equal to long term average values."

Regardless of the specific definition, droughts are difficult to predict or forecast, both as to when they will occur and how long they will last. According to Dr. Grant Darkow, Department of Atmospheric Science, University of Missouri-Columbia, there is a recognizable "upper air-flow pattern and simultaneous

surface pattern associated with abnormal dryness over Missouri." When the upper air-flow pattern is typified by air flowing in a broad arc over the central plains with higher speeds in southern Canada than over the U.S., then the air over the southern plains will be "characterized by a weak clockwise circulation." Storm systems coming off the Pacific Ocean will cross the extreme northwestern states and southern Canada, thus bypassing the midwestern states. When this flow pattern persists, the result can be a prolonged period of drought.

The most commonly used indicator of drought and drought severity is the Palmer Drought Severity Index (PDSI), which is published jointly by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA) (see Table D-1). The PDSI measures the difference between water supply (in terms of precipitation and stored soil moisture) and demand (the amount of water required to recharge soil and keep rivers, lakes and reservoirs at normal levels). The result is a scale from +4 to -4, at 1.0 and 0.5 intervals. By relating the PDSI to a regional index, one can compile data that reflects long-term wet or dry tendencies.

**TABLE D-1**

**PALMER DROUGHT SEVERITY INDEX (PDSI)**

| PDSI Number | Long-Term Tendency |
|---|---|
| Above 4.0 | Extreme moist spell |
| 3.0 to 3.9 | Very moist spell |
| 2.0 to 2.9 | Unusually moist spell |
| 1.0 to 1.9 | Moist spell |
| 0.5 to 0.9 | Incipient moist spell |
| 0.4 to -0.4 | Near normal conditions |
| -0.5 to -0.9 | Incipient drought |
| -1.0 to -.9 | Mild drought |
| -2.0 to -2.9 | Moderate drought |
| -3.0 to -3.9 | Severe drought |
| Below -4.0 | Extreme drought |

For PDSI reporting purposes, Missouri is divided into six regions of similar climatic conditions: Northwest, Northeast, West Central, Southwest, Southeast, and Bootheel. These regions are illustrated on Figure D-1 (Palmer Drought Severity Index, Missouri Subregions) in Section VII of this annex.

In addition to the NOAA/USDA indices, water management agencies in Missouri have access to the Missouri Crop and Weather Report, produced by the Missouri Agricultural Statistics Service. These reports provide detailed statistical information on weather conditions, crop conditions, topsoil moisture supply, and subsoil moisture supply by subregion throughout Missouri.

Other less quantitative indicators of drought include high water demand versus available supplies, reduced stream flows, declining reservoir levels, precipitation deficits, falling water levels in wells, and low soil moisture.

The difficulty with recognizing or predicting drought is that no single indicator can be reliably used to

predict onset. Regional indicators such as the PDSI are limited in that they respond slowly to deteriorating conditions, whereas observations of surface conditions and groundwater measurements or rainfall may only provide a "snapshot" of a very small area.

Consequently, the use of a variety of drought indicators is essential for effective assessment of drought conditions, and the PDSI is the primary means to assess drought severity.

Missouri's Drought Response System is divided into four phases:

1. **Phase I - Advisory Phase:** Requires a drought monitoring and assessment system to provide enough lead time for state and local planners to take appropriate action.

2. **Phase II - Drought Alert:** When the PDSI reads -1.0 to -2.0, and stream flows, reservoir levels, and groundwater levels are below normal over a several month period, or when the Drought Assessment Committee (DAC) determines that Phase II conditions exist based on other drought determination methods.

3. **Phase III - Conservation Phase:** When the PDSI reads -2.0 to -4.0, and stream flows, reservoir levels, and groundwater levels continue to decline, along with forecasts indicating an extended period of below-normal precipitation, or when the DAC determines that Phase III conditions exist based on other drought determination models.

4. **Phase IV - Drought Emergency:** When the PDSI is lower than -4.0, or when the DAC determines that Phase IV conditions exist based on other drought determination methods.

## III. HISTORICAL STATISTICS

According to the 2004 revision of the Missouri Climatic Atlas for Design of Land Application Systems 9MDNR-WP-1400) Missouri's average annual rainfall ranges from about 33.6 inches in the northwest to about 51 inches in the southern tier of the Missouri bootheel. Even the driest areas of Missouri have more rainfall than most western states; however, lack of rainfall impacts certain parts of the state more than others because of alternate source availability and usage patterns.

**Southern Missouri**—Most of the southern portions of Missouri are less susceptible to problems caused by prolonged periods without rain because of abundant groundwater resources in the region. Even with decreased stream flows or lowered reservoir levels, groundwater is still a viable resource in southern Missouri. Row-crop farming is not extensive, and therefore agricultural needs aren't as great as in other parts of the state. The only exception is in the southwestern and southeastern areas where irrigation is used.

**Northern And West Central Missouri**—Most of the northern and west-central portions of Missouri are underlain by rocks that are not conducive to water-bearing formations. They yield only small amounts of water, even during periods of normal and above-normal rainfall. Under drought conditions, adequate amounts of water cannot be pumped from the rock formations of northern Missouri to supply even domestic needs. Most streams in northern Missouri do not receive appreciable groundwater recharge. During periods of drought, these streams are generally reduced to a series of pools, or may become completely dry. Streams and water impoundments are the only localized sources of water during droughts, and even these limited resources are at risk when the drought is prolonged. Agriculture in west-central and northern Missouri is usually the first to feel the effects of drought. Although row-cropping is more extensive in this part of the state, irrigation is generally not feasible except on the floodplains of

major rivers.

**Drought of 1999-2000**

Most of Missouri, along with other states, was in a drought condition during the last half of 1999. The dryness did not begin until July 1999, but rapidly developed into a widespread drought by September. At that time, Missouri was placed under a Phase I Drought Advisory level by the Department of Natural Resources (MDNR), and Governor Carnahan declared an Agricultural Emergency for the entire state. Agricultural reporting showed a 50 percent crop loss from the drought in 50 counties, with severe damage to pastures for livestock, corn crops, and Missouri's top cash crop–soybeans. On October 13, 1999, U.S. Agriculture Secretary Dan Glickman declared all Missouri counties agricultural disaster areas, making low-interest loans available to farmers in Missouri and contiguous states. The drought intensity increased through autumn and peaked at the end of November 1999. In fact, the five-month span between July and November became the second driest July-November period in Missouri since 1895, averaging only 9.38 inches of rain.

A wetter-than-normal winter diminished dry conditions in central and southern Missouri, but long-term moisture deficits continued to exist. At the same time, the remainder of the state (roughly north of the Missouri River) continued under drought conditions. Overall dry conditions returned through much of the state in March 2000, and costly wildfires and brush fires (70) erupted in many counties. By May, the entire state was under a Phase II Drought Alert level, and on May 23, Governor Carnahan announced activation of the Missouri Drought Assessment Committee (DAC), made up of state and federal agencies and chaired by Mr. Jeff Staake the MDNR Deputy Director. At a May 25, 2002, meeting, the DAC selected a subcommittee (guided by the Missouri Drought Response Plan) to determine the drought status of each county. In June, based on observations across the state and projections of future rainfall, the committee in June upgraded the drought status for 27 northern Missouri counties to Phase III, Conservation. This was based on concerns for water supplies and agricultural impacts. The City of Milan in Sullivan County was among the most severely affected in terms of water supplies. In June, a total of 80 Missouri counties remained under the Phase II Alert level, while seven counties in southeast Missouri (Butler, Dunklin, Mississippi, New Madrid, Pemscot, Scott and Stoddard) remained under Phase I Advisory conditions.

By mid-July 2000, some areas of northern Missouri benefited from additional rainfall, while drier conditions prevailed in other areas. At its July 12 meeting, the DAC revised its assessment, placing 30 counties under Phase III Conservation conditions, including 10 counties in the south-central area. The remaining 84 counties in the state were under Phase II Drought Alert conditions. This included seven counties in northern Missouri, which were downgraded from Phase III Conservation, and seven counties in Southeast Missouri, which were previously assessed as Phase I Advisory.

To ease the agricultural impact of the drought during the summer months, Governor Carnahan gained release of over 1 million acres from the Conservation Reserve Program (CRP) to provide farmers and ranchers in 21 counties an additional sources to cut hay for livestock feed. Also, livestock producers in 16 counties were released from CRP contracts to allow cattle grazing on certain idle lands.

**Drought of 2002-2004**

The drought of 2002 caused tremendous financial hardships to many Missouri crop and livestock producers. The financial impact of the drought on producers in turn impacted the local communities and the state in terms of reduced economic activity. This drought cost an estimated $46 million in 2002 and $575 million for 2003 in terms of Missouri's agricultural and economic productivity.

Drought conditions encompassed most of the northwestern quarter of Missouri. Severe drought conditions affected the northwest, west-central, and some portions of southwest Missouri, causing water conservation measures to be taken and restrictions to be imposed. For some areas, this was the second driest year since 1914; the only drier year was in 1988. This was the driest November – December period on record for northwestern and north-central Missouri in 2002. The drought continued through 2003 and 2004 with conditions improving in 2004. As of March 3, 2004, drought conditions still encompassed most of the northwestern quarter of Missouri with 18 counties designated as being in Phase 3-Conservation Phase. The drought conditions improved due to an increase in precipitation between March and June 2004. In June 2004, Missouri was considered drought free for the first time in three years.

**Drought of 2005**

The Drought of 2005, as in the previous drought of 2003-2004, caused tremendous hardships to many Missouri crop and livestock producers. According to the University of Missouri's Food and Agriculture Institute (FAPRI), the estimated losses to the corn and hay crops alone will likely top $370 million. For some Missouri farmers this will be a drier year than 1988. By late July, the drought conditions encompassed all but nine counties in the northwestern corner of the state. Severe drought conditions affected counties in the southwest through the northeast part of the state. Effective August 23, 2005 due to the Secretarial disaster designation. 114 Missouri counties and the City of St. Louis were designated as natural disasters for physical and/or production loss loan assistance from Farm Service Agency (FSA). The drought conditions began to improve by late August and into September.

## IV. MEASURE OF PROBABILITY AND SEVERITY

Because of its geographical location and characteristic weather patterns, Missouri is vulnerable to drought conditions. Agricultural droughts are the most common on record, particularly those inflicting damage to corn crop yields. Throughout much of this century, these droughts have occurred with common regularity (on the average of once every 5 years), according to the Missouri Crop and Livestock Reporting Service.

Based on Midwest drought data, the Missouri Department of Natural Resources (MDNR), Water Resources Program produced a Missouri Drought Response Plan in 1995, with revisions in 2002. The plan's primary purpose is to address the need for state and local governments to coordinate advanced emergency planning, as during the drought of 1999-2000. The plan outlines proactive emergency and tactical measures designed to better prepare the state for drought. It also emphasizes the need for long-range strategic planning, which would address the bigger issue of drought impact avoidance. The plan notes that one of the major goals of drought mitigation is to prevent water shortages in the agricultural sector and public water systems.

In preparing the plan, divided the state into three regions, which are prioritized according to drought susceptibility. The regions are identified as having slight, moderate, and severe susceptibility to drought conditions. They are illustrated on Figure D-2 (Drought Susceptibility) in Section VII of this annex. Descriptions of drought susceptibility for the three regions are as follows:

**Region A (mostly Southeast Missouri)** has very little drought susceptibility. It is a region underlain by sands and gravel (alluvial deposits). Surface and groundwater resources are generally adequate for domestic, municipal, and agricultural needs.

**Region B (Central, East-Central Missouri)** has moderate drought susceptibility. Groundwater resources are adequate to meet domestic and municipal water needs, but due to required well depths, irrigation wells are very expensive. The topography generally is unsuitable for row-crop irrigation.

**Region C (Northern, West-Central Missouri; St. Louis County)** has severe drought vulnerability. Surface water sources usually become inadequate during extended drought. The groundwater resources are normally poor, and typically supply enough water only for domestic needs. Irrigation is generally not feasible. When irrigation is practical, groundwater withdrawal may affect other uses. Surface water sources are used to supplement irrigation supplied by groundwater sources.

The Missouri Drought Response Plan relies primarily upon the PDSI to indicate drought severity, and supports its findings directly with stream flow, reservoir-level, and groundwater-level measurements. Actions within the drought plan are triggered when the PDSI reaches certain levels. The DAC, chaired by the Director, or designee of the Department of Natural Resources, is activated in the Phase II Drought Advisory Stage. The DAC then activates the Impact Teams, which cover the topics of agriculture, natural resources and environmental recreation, water supplies, wastewater and health, social, economic, and post-drought evaluations. Areas that appear to be the most vulnerable to drought are the focus of future drought planning, management, and mitigation activities. Based on this information, the State rates the probability and severity of the drought hazard as moderate.

## V. IMPACT OF THE HAZARD

A severe drought in the Southern Plains states from the fall of 1995 through the summer of 1996 resulted in more than $1 billion in costs and damages to agricultural regions. The states of Texas and Oklahoma were most severely affected. In the summer of 1993, a combination of drought and a heat wave across the southeast U.S. was responsible for about $1 billion in costs and damages. Among the most costly disasters, however, was the Great Drought of 1988-1989, which caused an estimated $39 billion in losses in the United States. As a comparison, the record floods of 1993 in the Midwest inflicted damage in the range of $12 to $16 billion. Although more subtle in terms of physical damage, the social and economic costs of drought are substantial.

Drought, as it affects the health and safety of Missouri citizens, is primarily a problem of rural water supply. With some exceptions, larger municipalities have not experienced major problems at levels that have caused impacts to some smaller communities. Most seriously affected are those supplied by small water structures. In its scope, a drought may be limited to a localized problem, or even a regional problem. Based on severity and duration, it may even become a statewide problem, at least in terms of overall impact, such as the commitment and shifting of resources and other response issues. Good water quality and a plentiful supply are two factors that we often take for granted. But when good water becomes a scarce commodity and people must compete for the available supply, the importance of these two factors increases dramatically. The State Water Resources Plan (RSMO 640.415), which is a provision of the Water Resources Law enacted by the Missouri Legislature in 1989, requires MDNR to ensure that the quality and quantity of Missouri's water resources are maintained at the highest possible level to support present and future beneficial uses. The provision was established to provide for the development, maintenance, and periodic updating of a long-range comprehensive statewide plan for the use of surface water and groundwater. It includes existing and future requirements for drinking water supplies, agriculture, industry, recreation, and environmental protection, and related needs.

## VI. SYNOPSIS

In addition to damage to crops, produce, livestock, and soil, and the resulting economic consequences, the arid conditions created by drought pose an increased risk of fire. The danger is especially high for brush fires, grass fires, and fires in wooded areas, which can threaten homes and other structures in their path. Lack of water resources in rural areas can complicate the firefighting efforts. During the spring 2000

drought, brush and wildfires erupted in numerous counties, resulting in a Governor's declared State of Emergency. The fires in Camden County were the most severe (See Fires, Annex I, in this State Hazard Analysis).

Severe drought also poses health threats to citizens due to water shortages and extreme heat. Particularly vulnerable are children, the elderly, and those with respiratory problems. Contaminated or poor water quality for drinking and sanitation measures can also cause serious illnesses. The Missouri Drought Response Plan addresses issues regarding water shortages and can be accessed via the MDNR website: www.MDNR.mo.state.mo.gov/.

## VII. MAPS OR OTHER ATTACHMENTS

- Palmer Drought Severity Index: Figure D-1
- Drought Susceptibility: Figure D-2
- Drought Condition Status, July 29, 2005: Figure D-3.

**FIGURE D-1**

## PALMER DROUGHT SEVERITY INDEX
Missouri Subregions

**FIGURE D-2**

**DROUGHT SUSCEPTABILITY**

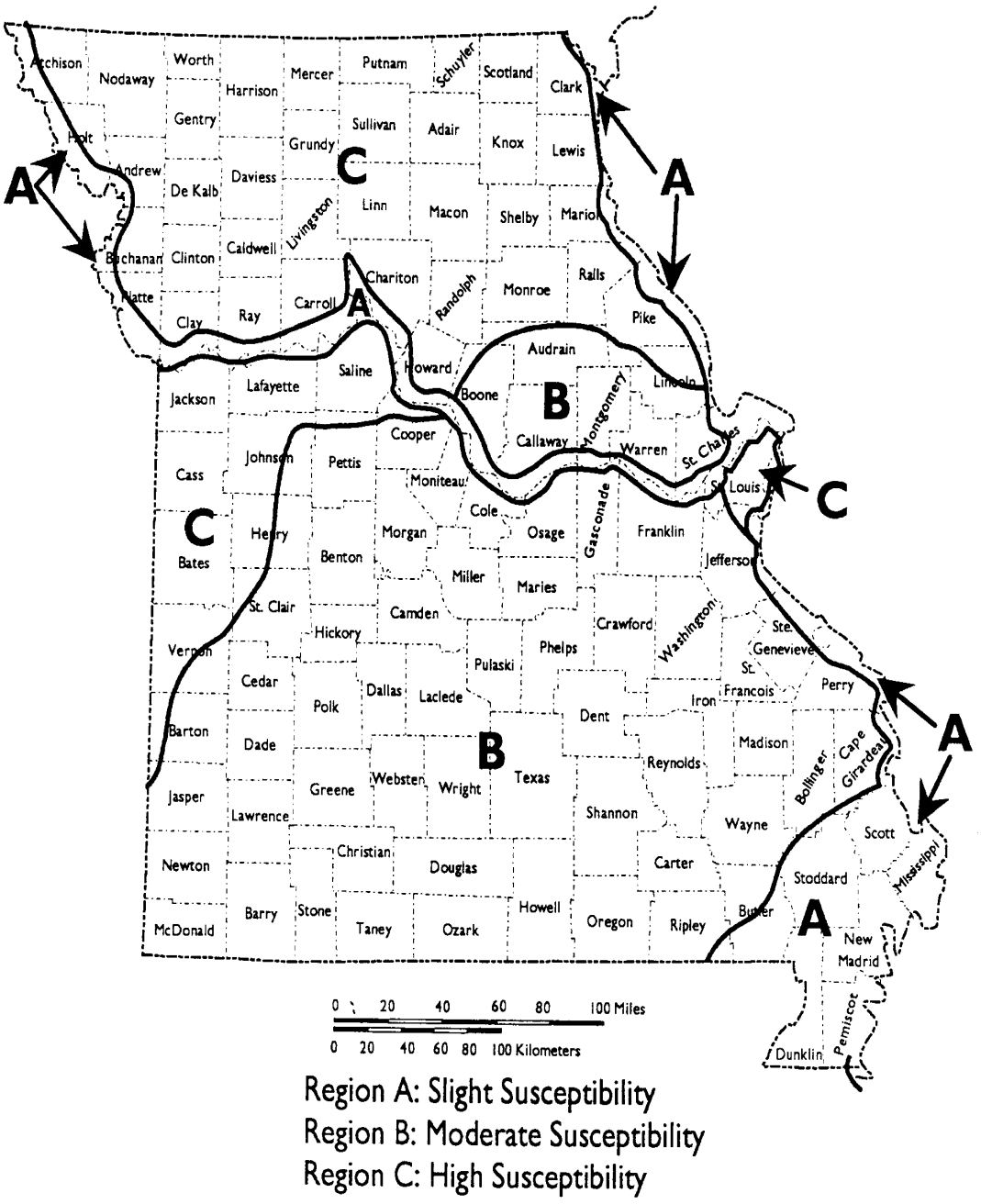
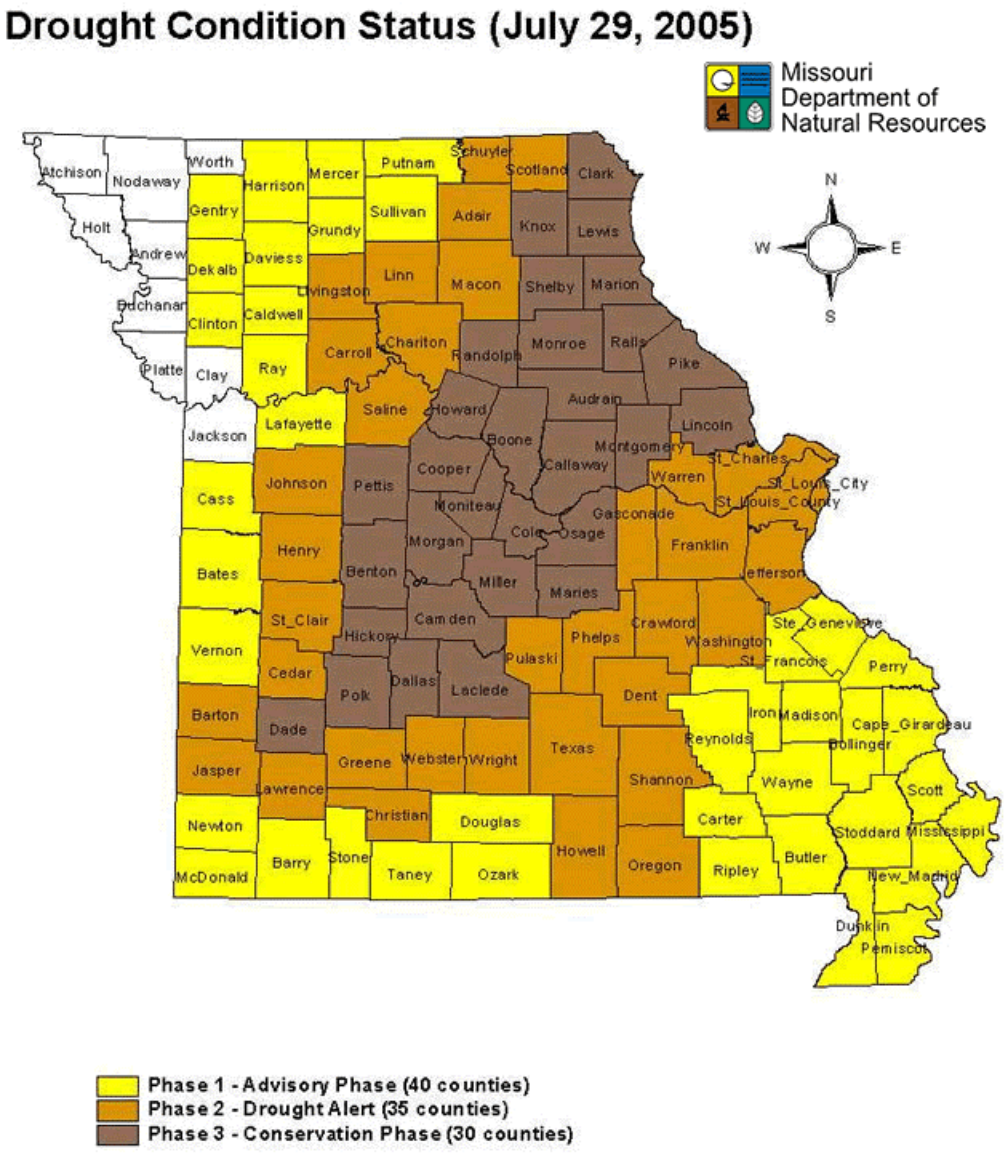


**FIGURE D-3**


Drought Condition Status (July 29, 2005)
Missouri Department of Natural Resources
N
W
E
S
Atchison
Nodaway
Worth
Harrison
Mercer
Putnam
Schuyler
Scotland
Clark
Gentry
Sullivan
Adair
Knox
Lewis
Holt
Grundy
Andrew
Dekalb
Daviess
Linn
Macon
Shelby
Marion
Buchanan
Clinton
Caldwell
Livingston
Carroll
Chariton
Randolph
Monroe
Ralls
Pike
Platte
Clay
Ray
Saline
Howard
Audrain
Jackson
Lafayette
Boone
Montgomery
Lincoln
Cooper
Callaway
St_Charles
Johnson
Pettis
Warren
St_Louis_City
Cass
Moniteau
St_Louis_County
Gasconade
Osage
Franklin
Henry
Morgan
Bates
Benton
Miller
Maries
Jefferson
St_Clair
Camden
Crawford
Ste_Genevieve
Vernon
Hickory
Phelps
Washington
Pulaski
St_Francois
Perry
Cedar
Polk
Dallas
Laclede
Dent
Barton
Dade
Iron
Madison
Cape_Girardeau
Reynolds
Bollinger
Jasper
Greene
Webster
Wright
Texas
Shannon
Wayne
Scott
Lawrence
Newton
Christian
Douglas
Carter
Stoddard
Mississippi
Howell
Butler
McDonald
Barry
Stone
Taney
Ozark
Oregon
Ripley
New_Madrid
Dunklin
Pemiscot
Phase 1 - Advisory Phase (40 counties)
Phase 2 - Drought Alert (35 counties)
Phase 3 - Conservation Phase (30 counties)

## VIII. BIBLIOGRAPHY


Darkow, Grant L. "Missouri Weather Patterns and Their Impact on Agriculture." Department of Atmospheric Science. University of Missouri. Columbia, Missouri.

Guinan, Pat. "Drought Impact, December 2002." University of Missouri. www.mcc.missouri.edu/imedec02.pdf.

Missouri Department of Natural Resources (MDNR). "Missouri Drought Response Plan." 1995. www.MDNR.state.mo.us/geology/wrp/wr_rpt_44.pdf.

MDNR. "Missouri Drought Response Plan." 2002. www.MDNR.mo.gov/geology/wrp/wr69.pdf.

MDNR. "The Palmer Drought Severity Index." "Missouri Drought Susceptibility Map." www.MDNR.mo.gov/geology/wrp/wr69.pdf.

MDNR. "July 29, 2005, Drought Status Map." www.MDNR.mo.gov/geology/droughtstatus-5-20-03.htm.

MDNR. Drought Information: www.MDNR.mo.gov/geology/droughtupdate.htm.